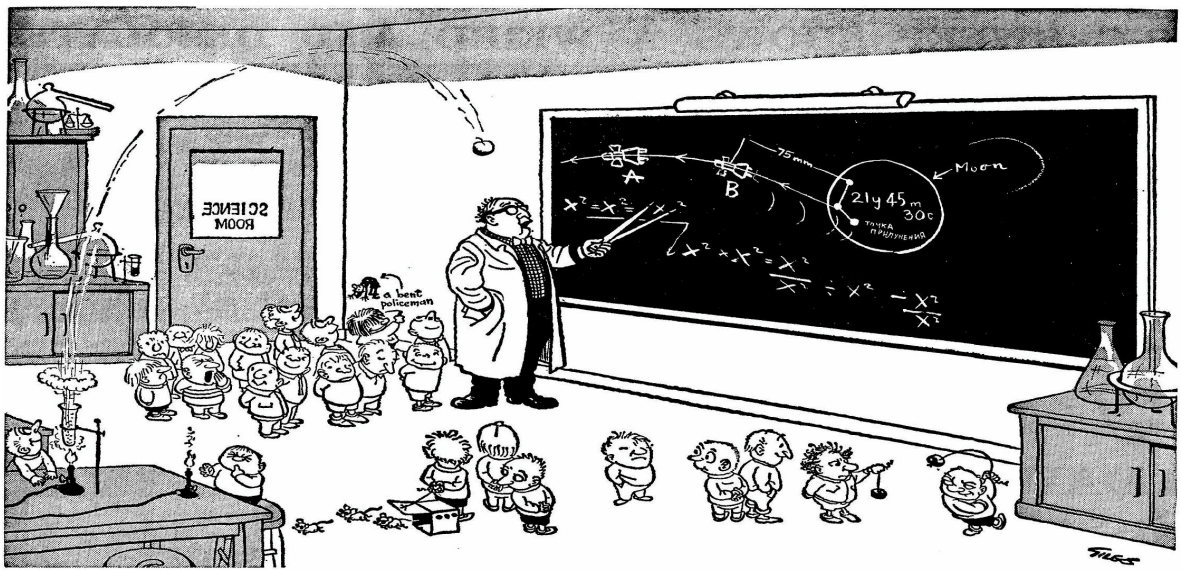
# G30 Successful Science Practicals

June 2009






"Now, instruments monitoring the space-probe's radio transmissions indicated a 'Doppler Shift' which is tantamount to a change in wavelength, or frequency, of a series of soundwaves caused by the movement between Luna and Jodrell Bank."

Acknowledgements:
Carl Giles, the Daily Express, 8th February 1966, the British Cartoon Archive, University of Kent, www.cartoons.ac.uk

# Contents






CLEAPSS
Brunel Science Park
Kingston Lane
Uxbridge
UB8 3PQ
*Tel:* 01895 251496
*Fax*: 01895 814372
*E-mail:* science@cleapss.org.uk
*Web Site:* www.cleapss.org.uk

# Successful Science Practicals
## (Organising and running a successful science practical lesson)

## 1 Introduction

Practical work has long been at the heart of school science. It is spoken of with fondness, enthusiasm and excitement. Scientists, politicians and teachers are always ready to recount tales of experiments that involved flashes and bangs, 'blowing-up the laboratory' and making 'terrible pongs'. As one eminent scientist, Sir Paul Nurse said, "Science is all about exploring the natural world around us. Teaching in schools needs to reflect the excitement and wonder of that quest for knowledge"[1].

When children arrive at their new secondary school they come with a background in practical science investigations. They anticipate that science is going to be even bigger and better because many will have already visited the secondary school and used a Bunsen burner or experienced secondary science teachers doing such exciting demonstrations as the howling jelly baby.

To meet pupils' aspirations and to enthuse them through practical work, science lessons need to be well organised, the teacher needs to be confident in her/his practical ability and have a good imagination. Good practical lessons don't just happen, they are well-planned, prepared, introduced and concluded. Pupils both enjoy the experience and learn a lot about science.

Don't forget, too, that there is an element of theatre about practical work, especially demonstrations. Rehearsal is time-consuming but vital. Children will understand and often sympathise with the teacher about the occasional 'failed' experiment but only if it doesn't happen too often.

This guide collects the many helpful hints and ideas which teachers and technicians have found lead to smooth-running and successful practical work. It will be useful to trainee teachers, those who are newly qualified, and the technicians who support them. It can also remind those more experienced that good practical work is welcomed by pupils and remembered by them long after the event. Finally, it can kick-start an interest in science which never leaves them.

To be successful and effective, practical work has to:

- be interesting, and even exciting;
- have a clear purpose, shared with pupils;
- be well planned, timed and managed to achieve its purpose;
- be manageable by pupils.

This guide presumes that the practical activities you plan are both interesting and exciting, and that you know why you are doing them. This guide is to help you make sure your practicals are well planned and managed so that you and your pupils can get the most from them.

[1] www.guardian.co.uk/education/2005/nov/28/schools.uk.

# 2 Planning and preparing your practical

No matter where you source your practical, from a text book, scheme of work or just out of your head, you must be clear what you want the pupils to learn and how you are going to manage that most effectively. Often called the *objective* for the lesson, your planned learning is also sometimes called *learning outcomes* or just *outcomes*. The name is probably less important that what is in your mind. Be clear but avoid being too ambitious. You cannot manage 4 or 5 objectives with a class of 30 pupils. With so many, at best you can only hope that some of the objectives stick for some of them.

When starting out keep it simple. Identify the one significant piece of learning that will build on what went before and prepare the pupils for what comes next. Explain what you anticipate for them from the work and make sure you finish your lesson by checking to see if the learning was achieved.

Once you know what practical you want and why then the rest is about making it happen successfully. The elements of this, described in the rest of this section, are completing a requisition sheet for your technician, trialing the activity, and risk assessment.

**Tips**

In lesson planning, teachers of practical subjects should aim to be thinking at least 2 lessons ahead of the current lesson for any class, which is why you have to be highly organised and disciplined.

Some activities are seasonal. Think carefully about asking for daffodil flowers in September or carrying out photosynthesis experiments in the depths of winter.

## 2.1 Requisition sheets – *technicians are not mind readers*

The requisition sheet is an essential communication between teacher and technician. It emerges from careful planning by the teacher who can also benefit from good feedback from the technician. There is no one best style of requisition: all sorts are equally useful. However, to prepare for a successful practical the technician needs to know:

- the name of the teacher;
- the laboratory in which the practical is to be carried out;
- the day and lesson for the practical;
- the year group and class;
- any reference to a written practical, often in a scheme of work;
- a title for the experiment. Experienced technicians might have provided similar equipment previously and have hints and tips to make your practical session more successful;
- alternatively, a clear list of equipment and other resources required;
- all relevant details clearly stated, eg, the molarity of the acid required or which ‘experiment 16.3’;
- whether the materials are for a class practical, with the number of sets required, or are for a demonstration or circus;
- if the experiment is to be repeated with another class;
- any health and safety information relevant for the technician where appropriate;
- if it is part of the technician’s job to provide any worksheets or other resources needed to accompany the practical.

Below is an example of a requisition sheet for an activity involving 'testing of a leaf for starch'. It is thorough, provides all the information the technician needs, and it offers the technician the opportunity to feed information back to the teacher. It can be kept from year to year and easily amended in the light of the experience because it is computerised. It also helps establish and maintain good relationships between teacher and technician.

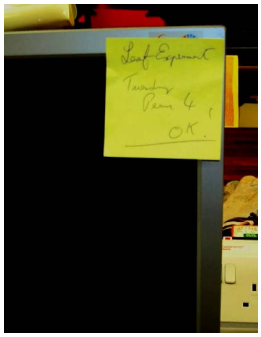
Example Requisition Sheet

| Teacher | | | | | | | |
|---|---|---|---|---|---|---|---|
| Day/date | Mon | Tues | Weds 4th | Thurs | Fri | | |
| Lab3Room | Lab1 | Lab2 | Lab3 | Lab4 | Lab5 | Lab6 | Lab7 |
| Lesson | 1 | 2 | 3 | 4 | 5 | 6 | |
| Year | 7 | 8 | 9 | 10 | 11 | 12 | 13 |

| Technician will highlight the responses | | |
|---|---|---|
| Experiment title | Testing a leaf for starch | |
| Experiment reference | Activity AB7.2 | |
| Equipment | Quantity | Comment or reference |
| *Fresh soft leaves that have been in strong light* | *30* | |
| *Kettles* | *Need 4* | |
| *Forceps* | *15* | |
| *0.1 M iodine solution in dropper bottles* | *15* | *CLEAPSS Recipe card no 39.* |
| *Test tubes* | *15* | |
| *Washing up bowl* | *1* | |
| *Eye protection sign* | | |
| *Industrial Methylated spirits* | *1 container – approx. 200 ml.* | *See Hazcard 40A.* |
| *Beakers* | | *To be used as hot water baths.* |
| | | |

| | |
|---|---|
| Teacher notes and control measures for the class | Wear safety specs. Put all test tubes in the washing up bowl at the end. Need to count the forceps in. No Bunsens or naked flames on when the meths is being used. |
| Notes to technician including preparation control measures | Need to put the leaves in a box 24 hours beforehand. Teachers: meths is now called industrial denatured alcohol. |

A note left on the computer screen on Monday evening for a practical on Tuesday is not going to endear you to the technician. They are busy people with many talents but surprisingly mind reading is not at the top (although many of them learn the knack of reading teachers' minds). Technicians need a few days notice, and more if local purchases are required. Many schools have a policy for the week's requisitions to be handed in on Thursday lunchtime for the following week.



Requisitions should always be provided in writing; a verbal 'Can I just have … next week' will never suffice.

**Tips**

New teachers have a lot of information to take in when starting in a new school so colleagues (teachers and technicians) will need to give them several gentle reminders before systems are adhered to.

Technicians can play an important role in the training of new teachers. Encouraging new teachers to adhere to technicians' systems, and understand why this is necessary, will stand them in good stead in their future teaching careers.

It is valuable to involve technicians at the planning stage. Technicians can often suggest additional resources or a different way of doing a practical that may be better. Some teachers set aside half an hour per week to discuss requisitions with the technicians and are inspired by this practice.

For a science teacher, working with the technician is crucial to providing effective lessons. A student teacher should try to shadow the technician and understand the work that s/he does.

(Schools use a variety of requisition sheets. References to these and other useful document can be found in appendix 2.)

## 2.2 Trialing practical activities

**Trialing practical activities is one of the most important elements in planning your lesson.**

Practical lessons are busy times. Don't expect to be able to think your way through a practical as you go because much of your time will be taken up with managing the activity and responding to pupils' questions. New teachers are often surprised by the range of questions that pupils will ask, such as: is that enough water in the beaker?; Is it green enough?; If I drink this alcohol, will I get drunk? Answering all of these, and often the same question several times from different pupils, will occupy much of your attention. You therefore need to understand the activity itself in advance of the lesson.

Find a good place to carry out your trial. Barging in to a busy prep room when you have a non-contact period is not going to endear you to the technicians. Try an unused laboratory. If you plan to trial before or after school be careful of lone working. If you are doing an activity that involves materials or equipment that are hazardous, then make sure there are other experienced science teachers in the vicinity.

Trying out an activity yourself will identify:

- how long it takes; pupils will take at least three times as long as you did;
- whether any written instructions are clear;
- what verbal instructions you will want to give, and when;
- whether you will want demonstrate handling some or all of the equipment;
- what sort of questions the pupils might ask;
- what sort of questions you will want to ask;
- how much movement around the lab might be needed, eg, to collect and return equipment;
- possible extension activities for pupils who work quickly.

**Tips**

If you have the services of a TA or HLTA arrange for them trial the activity with you (or at a later time with supervision) so both of you know what is going on and you can work as a team.

If it is possible to video the trial, the video could be used during the lesson to emphasise various points to the pupils, for revision at a later date or, in the last resort, as a substitute for doing the practical if for some reason is becomes impossible.

**Worksheets**

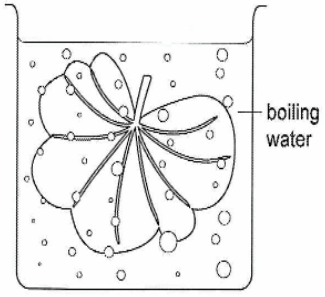
Don't unquestioningly trust worksheets or instructions. The worksheet overleaf is for a fairly standard activity, testing a leaf for starch. Questions to which the answers are not obvious include: what size beaker is required?; Does each set of pupils need two beakers?; Is it a boiling tube or test tube? Others that will emerge include: how much ethanol do we need? (now called IDA but was for some time called IMS); what safety precautions are needed?; Might so much boiling ethanol shoot out of the tube?; Will the forceps fit into a test tube?

After trialling, a second version of the worksheet was produced which deals with many of these potential problems.

# Testing a leaf for starch

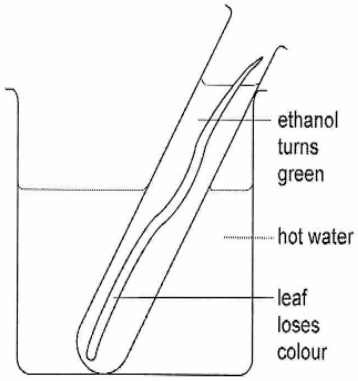
YOU MUST WEAR EYE PROTECTION

**a** Place the leaf in boiling water until it goes soft. (Use hot water from a kettle or water bath.) The cells are now permeable. Put the leaf into a boiling tube.



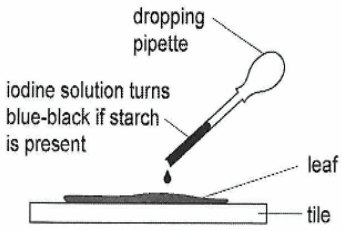

**b** Cover the leaves with ethanol (HIGHLY FLAMMABLE – no naked flames) and place the tube in hot water.

**c** Remove the leaf when it is colourless. The chlorophyll will have dissolved in the ethanol.

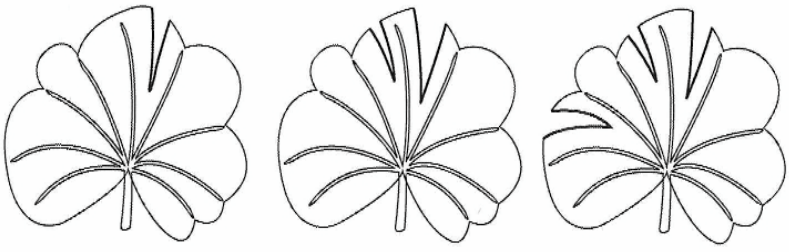



**d** Rinse the leaves with hot water and spread them on a white tile.

**e** Add a few drops of iodine (stains clothing and skin).




You can test several leaves at the same time if you cut shapes in their sides to identify them.



control | leaf without light | leaf without carbon dioxide

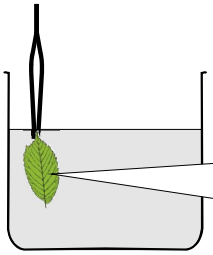
*A code to identify leaves after testing*

# Worksheet modified after a trial

## Testing a Leaf for Starch

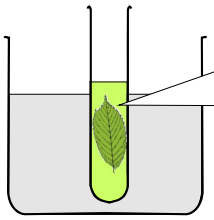
### Wear eye protection

- Organise your equipment.
- Ask the teacher or technician to pour boiling water into the 250 ml beaker.
- Hold the leaf with the forceps and place it into the hot water for 1 minute.



What does this do to the leaf?

- Place the leaf on the tile.
- Fold the leaf if necessary.
- Remove the bung from the test tube and use the glass rod to push the leaf into the ethanol.
- Place the test tube in the boiling water.

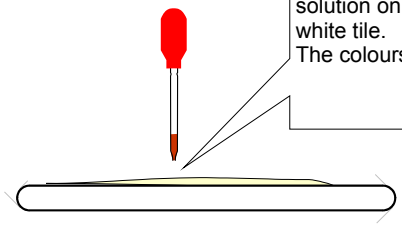


What do you observe happening to the colour of the ethanol?

- After 3 minutes, remove the leaf with the rod and forceps, then place it on the white tile.
- Dispose of the ethanol.
- Add one drop of 0.1 M iodine solution onto the white tile.
- Now add one drop of 0.1 M iodine solution onto the leaf and observe any colour change.

**Disposal**
**Please put the green ethanol in the provided bottle.**
**We shall purify the ethanol by distillation in another lesson!**

Compare the colour of the iodine solution on the leaf to that on the white tile.
The colours are...?



### Extensions

The ethanol (IDA / IMS) is on the side bench for you to pour out.

- There are plants in the cupboard that have been kept in the dark for 24 hours. Is there any starch in these leaves?
- There are variegated leaves. Do your own investigation of the white section.
- There is a plant that has been kept in a polythene bag containing potassium hydroxide solution to remove carbon dioxide from the air. Ask the supervisor to cut off a piece of leaf for you to test.

Remember that the changes introduced in this modified worksheet will affect some details in the requisition sheet illustrated on page 3.

### 2.3 Risk assessment

It is the teacher's responsibility to consult a risk assessment and to make any adjustments that might be necessary for the class and circumstances of the particular lesson. The science department will have a system for making and communicating risk assessment for practical work. You should know what the system is and adhere to it.

Following trialing, further adjusting risk assessing is likely to be a natural process. "How can I make the practical lesson run smoothly and safely?" For example, to manage the possibility of ethanol being accidentally ignited, you might choose to distribute the ethanol yourself or ask your technician to do it, rather than let individual pupils collect what they need.

You can find more guidance on risk assessment in science in the CLEAPSS guide L196*, Managing Risk Assessment in Science* (see Appendix 2).

# 3 Managing a practical lesson

The following points become part of the intuitive repertoire of a science teacher. However, for the new science teacher they are a useful checklist.

## Basic organisation

**How many in a group**

The usual number is 2, because with 3 one pupil can easily disengage and take little or no part. However, availability of equipment may be a restriction, and sometimes it is more manageable to deal with 10 groups of 3 rather than 15 groups of 2.

**Ordering equipment**

It is always worth ordering extra materials. Someone is bound to make a mistake and have to start again.

**Pupils with health issues**

The school should inform teachers about pupils with known health problems. These will include asthma sufferers, those with eczema, some with skin sensitivities etc.

**Emergency shut-offs**

You should know where the controls for the laboratory services are so that you can turn them off in an emergency.

**Seating arrangements**

Have a seating plan and stick to it, at least to start with. It will help you learn pupils' names. Change it when you, and not the pupils, decide. In difficult circumstances, you could announce the groups and seating outside the room before pupils enter. Don't be afraid to move groups or individuals to suit your planned activities.

**Technicians in lessons**

If they have time, technicians can be extremely useful in demonstrating to pupils how to use equipment or a particular skill, such as aseptic techniques, soldering and titration.

**TAs and HLTAs helping in the lesson**

Depending on their experience TAs and HLTAs can demonstrate techniques as well as support pupils. Involve them in trials and remember some may need some special tuition and help with the techniques.

## Worth looking out for

**Stand or sit for practicals**

Pupils should stand, rather than sit, during practical sessions with chemicals or when heating so that they can move quickly away from spills etc. Stools should be placed under the bench. Sitting down is better for titration, using a microscope, microbiology work, setting up electrical circuits, and some microscale activities with chemicals, where only drops are used.

**Clothes and hair**

For laboratory work, ties, scarves and sleeves, etc. must not hang freely. They can soak up chemicals from spills and some loose-fitting synthetic fabrics are flammable. Long hair should be tied back. Wear sensible shoes yourself, ones that are easy to remove if a liquid is spilled. Open-toed footwear is not advisable.

**Bags**

Pupils carry around heavy bags containing books, sports gear, etc. As these can lead to clutter in the laboratory, it is essential to find space for them so that only the minimum number of books is on the bench and no bags block gangways or become a trip hazard.

**Eye protection**

Eye protection is often not comfortable, and poorly stored so it becomes scratched. Pupils will perch safety spectacles on their heads and hang goggles loosely around the neck. Throughout a practical lesson, remind them to wear their eye protection **and remember to wear your own**. Any risk assessment should attempt to use the most comfortable eye protection. Goggles are often not as comfortable as safety spectacles. Wearing prescription spectacles is not a substitute.

## Nice (that make teaching a worthwhile vocation)

**Helping with skills**

Circulating around the class, offering encouragement and praise as pupils get to grips with a skill reinforces their confidence. Intervene when pupils are struggling, and help on a one-to-one basis. The process is very rewarding.

**Helping in understanding the work**

You may have identified certain questions to reinforce what pupils are doing and learning. It is even more rewarding when pupils ask you questions. Never be afraid of saying "I don't know but I will find out", but do remember to respond. Sometimes responses have to take the form of "In the last lesson Jane asked just how the carbon dioxide links together. Well this is a tough one to answer and you will find out more in the 6$^{th}$ form and university, and there is still research being carried out. Here is a picture of the Calvin cycle and…". Use the opportunity to impress the pupils. Show off, and demonstrate that you are passionate about science.

**Helping in extending the work**

You will notice some will finish early. For them you have extensions ready. For example, "Go and open that cupboard and you will find a plant which has been kept in the dark for 24 hours, test a leaf for starch. Tell me what you find out and try to explain why.".

## Nasty

**Dealing with an emergency**

You should be familiar with the immediate remedial measures on *Hazcard* E and section 5 of the CLEAPSS *Handbook*. Even if you are having a panic attack in your head, your actions should look calm and calculated. To flush an eye with water from a tap, you may need to physically hold the pupil steady. In the meantime, you may need stop the pupils doing the experiment as you are not in overall control, but you will need to send at least two pupils to obtain help from the technician.

**Theft**

You will be told by the technician that what goes out should come back. To avoid theft make it plain you are counting the equipment out and will count it back, for example, by having the technician bring the particular equipment in separately, loudly telling you how many you have, and returning before the end of the lesson to collect them. Avoid seeming to challenge the ingenuity of the pupils to steal the equipment. Syringes and scalpels need to be rigorously monitored. In some circumstances a demonstration may be a better alternative to class practical. Divided trays with compartments for individual items of equipment, such as stopwatches or magnets, makes checking returns very straightforward.

**Unauthorised experiments**

You can avoid most of these by good planning. However, be aware that pupils appear to enjoy investigating what happens when a biro is put in the Bunsen burner flame – it melts and burns producing toxic fumes. Know where the gas shut off is and use it judiciously.

**Interference**

There must be no interference by one pupil with another pupil's work, such as altering chemicals, switching off their stop clock, switching labels or squirting water (or a dilute solution). Particularly nasty is putting equipment in another's pocket or bag so it looks like they have stolen them. Wash bottles can be large water pistols to some pupils. These bottles should only ever contain water and their control needs to be strictly supervised.

**The mobile phone**

There will be school or department rules on the presence of mobiles in lessons. Make sure you understand what they are and take early advice from more experienced teachers on what to do with transgressors.

# 4 Timing the practical lesson

Work backwards when planning the timing of a practical a lesson. How long will it take to clear away, discuss any activity, the results and what can be learned from them, and set any homework? You may well need at least 15 minutes to ensure that the apparatus is returned to the trolley, waste chemicals are placed in specified containers and dirty glass is left out for cleaning, also remembering that the technician may have asked you to count in certain apparatus.

Allow pupils 3 times as long as it would take you for the practical activity. Some will finish earlier which is why it is important to have extension tasks. Others will struggle, and coping with this is a part of the art of teaching. If you can help all pupils with your ‘dashing expertise’ they will certainly develop a respect for your abilities.

You can now identify how long you have for the opening session. If you take too long then something else will have to go. It might be the practical itself, in which case you will have wasted your technician’s time and effort. If you cut short on cleaning up then be prepared to lend a hand yourself. At all costs try to avoid losing the time for considering what has been learned, but if this is impossible then make sure you devote the beginning of the next lesson to it.

If you work to a 50-minute period, tidying up, etc, reduces it to 35 minutes. If you took 7 minutes to do the basic practical in the trial, that means 21 minutes for the pupils and leaves 14 minutes at the most to introduce and get organised. The time soon disappears. No doubt there will be time for introductory questions but don’t rush the instructions.

Overall, this means you need a prompt start and finish to your lessons. Losing 5 minutes as pupils drift in from previous lessons or break can mean the success or not of a planned lesson. Be on time yourself, insist pupils settle quickly, and you will generally find that your classes adapt to your demands and your lessons will achieve what you planned.

# 5 Presenting equipment to the class

Apart from some post-16 lessons and practical exams, it is impractical and often undesirable to have equipment on benches at pupils' workstations at the start of a lesson. Pupils will fiddle with anything in front of them along with the obvious questions, 'have we got a practical?' and 'what's this for?'.

The following summarises possible arrangements for managing how pupils are given or collect equipment and materials for a practical activity.

**Lump it all together in one place**

This is quick for the technician and if the request is late, all that the teacher deserves.

The problem is that to avoid the inevitable scrum, each group will have to come out in turn and will probably not pick the all the equipment they require. ('Do I need these tweezers?') How do you know one group haven't taken 2 forceps so the last one have no forceps and you then have to send the pupils to the prep room?

**Separate the equipment out**

The equipment can be arranged around perimeter benches, one tray per type of equipment. Each group of pupils has a 'gofer' that walks in clockwise around the room and back to her/his place. If the pupils have to work on the perimeter bench, the teacher's bench and technician trolleys will have to do.

**Provide individual sets**


This is much quicker for the teacher but takes longer for the technician set it up. If, say, you have 3 benches each with 4 working groups, the technician can make up three trays with 4 white tiles, 4 beakers, 4 forceps, 4 leaves, 4 test tubes with 8 ml of ethanol and 4-iodine bottles. In the picture, all except the white tile can be put in the beaker.

**Provide 'measured doses'**

The technician measures the amount of some (or all) of the reagents needed and puts it out in containers which the pupils collect and take back to their workstation. The 8 ml of ethanol above is an example. It avoids a rush of pupils pouring ethanol into measuring cylinders (with the high risk of a spill) and then pouring it into a test tube.

**Weighing by pupils**

Queuing for a balance is an opportunity ripe for poor behaviour. It can be solved by providing a 'measured dose'. Alternatively, tell pupils to weigh accurately an adequate amount of a chemical. For example, between 1.5 and 2.0g. As long as the pupils weigh what they take accurately, how much they take is not so critical, and requires less time at the balance.

**Kettles, water baths, etc**

These should be separated from where the pupils work. The 'gofer' can collect a beaker of hot water and bring it back to the bench.

**Decanting from large bottles**

It is unwise to require pupils to pour from large bottles (eg, 2.5 L Winchesters). They are difficult to manage by adults let alone children. Solutions should be decanted into smaller labelled containers.

**Dispensing solid chemicals**

Place the chemical in a beaker or Petri dish, with a spatula, some distance from other solid chemicals.

**A case study from a technician**

"Recently they were doing decomposition of carbonates and we weighed out 10 lots of 5 carbonates for the class. Each boiling tube was individually labelled and placed in a litre beaker, which was also labelled. All the class then had to do was heat the boiling tube and note what happened. The used boiling tubes then went back into the litre beaker for us to remove. The teacher involved always gives us plenty of time, as he knows it makes his lesson run smoothly."

# 6 Practical instructions for pupils

Practical instructions need to be clear to the pupils. A new teacher must assume that instructions should be given several times, and in different ways. Pupils are not always as attentive as we might hope and, even if they are, there is no reason why they should understand complex instructions, which involve unfamiliar words, first time around. Don't assume that because you know what you mean, everyone else will.

**Write it up on the white board**

It takes time to write on a board but the slowness does stop you from going too quickly and confusing the pupils. Can they read your writing? Typing or writing using an interactive white board makes it is easier to see the instructions (unless strong sunlight makes the board hard to see) but pre-prepared instructions risk an all too common temptation to go through them too quickly.

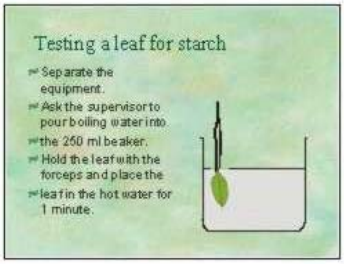
**Follow the instructions on the sheet**

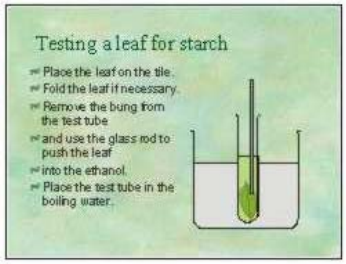
Following written instructions is an important skill to develop. We need it with to work all sorts of gadgets, in cooking, DIY, driving and gardening. However, a classroom has so many distractions it is difficult to for a pupil to close her/his mind enough to follow them.

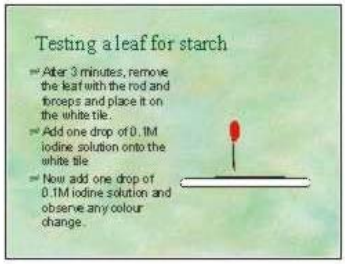
Remember that in science lessons, pupils are frequently venturing into the unknown and may be constantly asking "is this right?" Be reassuring, and just occasionally avoid telling the pupils "that's what it says on the sheet".

**Using PowerPoint animations**

Diagrams on a worksheet can be incorporated into PowerPoint presentation that can be animated to move automatically through a sequence allowing you to explain the process. This is often more time-consuming than you might imagine.




**Simulated demonstrations**

Using a set of equipment you can demonstrate the activity but without using the chemicals or taking readings. This works well for relatively simple activities.

**Full demonstrations**

Do the complete demonstration but you can increase engagement by inviting some pupils to undertake various parts of it. Having seen the whole activity the pupils then do it for themselves. This is particularly useful if you are showing a very important, delicate or intricate technique.

**Showing a video**

This is never a good substitute for doing the practical but can be useful to demonstrate a technique, particularly if the film was made in-house. It may be possible for an assistant to film parts of your trial activity with a digital camera, taking still or movie bursts. These can also be incorporated into PowerPoint presentations. Avoid showing the results, which would beg the question from some pupils, "why do they need to do it, once they have seen the result on the video?".

**Fragmented instructions**

The individual instructions are printed in a jumbled sequence for the pupils to cut out and order (but there may not be a single appropriate sequence). It forces the pupils to engage with the sense of the instructions. You may find that have to alter the wording slightly. Below is an example with the 'extracting starch from a leaf' activity.

- Hold the leaf with the forceps and place the leaf in the hot water for 1 minute.
- Place the leaf on the tile, Folding the leaf if necessary.
- Ask the teacher or technician to pour boiling water into the 250 ml beaker.
- Place the test tube in the boiling water.
- Add one drop of 0.1M iodine solution onto the white tile
- Remove the bung from the test tube and use the glass rod to push the folded leaf into the ethanol.
- Place the waste solution in the special bottle provided for disposal.
- Now add one drop of 0.1M iodine solution and observe any colour change, comparing the colour to that on the white tile
- After 3 minutes, remove the leaf with the rod and forceps from the coloured and place it on the white tile.

# 7 Ending the practical

With 15 minutes to go before the end of the lesson, it is time to stop practical work. During the lesson you may have seen some rather interesting results, discoveries or events. Tell the pupils to keep any particularly interesting ones to one side so you can use them in the last part of the lesson.

**Tip**

With a digital camera, you can take photographs of any interesting results. They could be copied passed around the class in another lesson or displayed on a notice board or in a PowerPoint presentation.

## 7.1 Clearing up

You will need as clear instructions for this part of the lesson as for the practical itself. Keep it simple by aiming to get pupils to return as much as possible to where it came from. This will include routine equipment stored in the lab and materials provided by the technician. Don't forget to count equipment back in, including items that may not be either potentially harmful or expensive. If there is a specific place for all items of equipment then any missing items may be quickly identified (by teacher, technicians and pupils) reducing the need for counting. Establish a routine of clearing up properly and thoroughly.

The science department health and safety policy should stipulate that teachers and pupils make sure that materials left for disposal will not cause harm to technicians, or cleaners, who, when clearing up later on, might be unaware of any hazard.

All this means that:

- in the main, avoid anything other than paper being put into the waste bin;
- any glassware containing chemicals that need careful disposal should be emptied into a relevant container and the glassware placed in a bowl;
- other glassware should be rinsed out immediately after use by those using the equipment, and placed in a convenient position for technicians to collect it;
- all bottles should have the correct stopper replaced;
- unused chemicals and other materials should be returned in their original containers to a convenient collection point;
- biological 'debris' should be placed in a suitable bowl;
- apparatus stored in the laboratory should placed tidily away in containers / drawers;
- specialist equipment provided by the technician should be returned to convenient collection points;
- sinks should be rinsed with water, so that no solids remain (especially iron filings which produce copious, hard-to-remove rust stains);
- benches should be wiped over with a damp cloth or paper towel to clean up small spills and to remove any water lying on the surface;
- for activities involving chemicals or biological materials pupils should wash their hands with soap and water.

# 8 Demonstration practicals

Demonstrations allow you to show pupils a scientific event that might:

- involve expensive and/or delicate equipment;
- involve particularly hazardous materials or equipment;
- be quite complicated;
- be difficult to do;
- have outcomes which are not easy to identify;
- take the pupils too long for the lesson;
- be a bit too noisy or consume too many materials for a class to do;
- need to be done quickly to introduce a topic, set the scene for a lesson or draw a lesson to a close.

Older teachers and some of their erstwhile pupils can recall demonstration which were major events, involved complex equipment and reactions, and took a whole lesson to perform including requiring pupils to draw and label the equipment. You can still do many of these if you choose, as long as they, and any other demonstrations you perform, satisfy the following points.

**Demonstrations must be appropriate**

Demonstrations for their own sake have a limited effect on pupil's learning. To carry out the howling jelly baby demonstrations to gain 'street cred' will not work. CLEAPSS also has concerns about doing demonstrations just because its Christmas or for open evenings. (See Guidance leaflet PS58.)

**Be well prepared and rehearsed**

Try to hang on to this rule of thumb - *Prior Practice Prevents Poor Presentation*. When you rehearse, carry out the demonstration for real, don't just go through the motions. Even if you change a bottle of a reagent, it would, be as well to retry the demonstration. For example, thermite reactions depend upon both the quality and size of aluminium grains. The reaction might not work with a new bottle if the powder has a thick oxide layer on it.

Data logging is notorious for going wrong, especially if you have to change rooms.

**Make sure the demonstration can be seen.**

Use as large-scale equipment as possible. Use a boiling tube rather than a test tube. 'Test tube' experiments can often be carried out in gas jars or 250 ml measuring cylinders but these are usually made of soda glass so must not be heated with a Bunsen burner.

If scaling up is potentially unsafe, you can use a flexicam, web cam or video camera attached to the projector. One of the pupils might enjoy operating the camera, as long as it is safe to be close to the demonstration.

Use a collection of coloured sheets or cards (or coriflute) to act as background to highlight the demonstration.

**Work from a clutter-free bench**

There should be no books or other equipment on the bench, not always easy if the teachers use their lab as an office. Sometimes it's better to move to a pupils' bench which also changes the visible focus of the lesson. For instance the 'alcohol gun' can be set up at the rear of the laboratory; the pupils can line up down each side as you fire the cork down the length of the laboratory.

**The impact should not take too long**

You may well lose pupils' attention if nothing happens for a minute. For example, clock reactions stay clear for a while and suddenly go black. For these kinds of demonstrations pupils will readily report "I didn't see it. Do it again.". It's as well to be ready for repeats.

**Develop a sense of drama**

Virtually every demonstration benefits from a sense of theatre, which is not as hard to achieve as might be imagined and a lot stems from your own enjoyment of the activity which pupils will pick up on. You can learn from those who practice magic, game show hosts and other presenters on the television and in the theatre. Some techniques include:

- use stories to set a scene, to build up tension or reduce it after a demonstration. You are almost certain to have some in your background which merit retelling;
- enjoy your own skills, for instance, after a nifty piece of manipulation comment on how slick you have been;
- if you make a loud bang and the pupils ask you to do it again then act as though you cannot hear them;
- some scientific phenomena are quite magical - use this to your advantage. For example, when operating an electron beam Maltese cross tube Teltron tube, you can invite a pupil to see if they can move the shadow by the power of their mind. You can do this, because you have concealed a magnet in your hand and as you pass you hand over the tube with added facial contortions, you make the shadow move.

**Ask questions**

By careful, planned questioning you can maintain attention and steer the class to a particular issue that you wish to focus on.

**Anecdotes**

Gather relevant stories and information from books, newspapers, radio, television and the Internet. This is especially useful if you have to do some careful manipulation. Never let the room go quiet. Either you speak or you ask questions.

The chip pan fire is a spectacular demonstration (See the *fat pan fire*, CLEAPSS guide L195, section 9.5). You can accompany it with the following information: ‘Did you know that 20 people are injured every day in accidental fires that start in their kitchen, the most common of these are caused by deep fat frying. In fact, more people die because of fires started by deep fat frying than children killed by strangers, although you would never think it was the case when you read the news’.

**Choose carefully when to give the game away**

For some demonstrations you need to tell the pupils what you expect to happen or what they will see so they can be ready for it, for example the magnesium / copper oxide flash which has unpredictable timing (see Hazcard 59A). With others this would spoil the impact. With the fat-pan fire, you can say ‘well we have shown how to put out the fire with a wet cloth or a metal tray, what would happen if I pour water over it?’.

**Avoid being impetuous**

In the heat of a lesson and in response to a pupil’s comment or question, a good demonstration may come to mind and you may be tempted to try it out there and then. Don’t. The best strategy is to say “you have reminded me of a demonstration, which I will organise for our next lesson”. That way you can plan the demonstration properly, avoid disrupting your current lesson and avoid creating havoc by a sudden request for equipment. But make sure you do the demonstration.

**And what if it does not work**

This happens to all teachers of science but don’t let it happen in the first lesson you have with a class. You may be able to get some points across if you ask; Why didn’t it work’ but don’t let it go on for long. You do not want the reply ‘Because you’re rubbish!’ or words to that effect. If you have already had several successful lessons and demonstrations, the pupils will understand that not everything goes to plan. It is better to explain that you will sort it out for the next lesson and leave it at that.

# 9 Developing and extending your skills

The majority of work you carry out in the school focuses on the pupils. However, you must make time for your own development not only as a communicator but also as a practising scientist. You will not have learnt all these skills at college or university and you should take every opportunity to extend your repertoire. The following is a list of some of the many initiatives, organisations and websites that offer help.

**'The Wise Owl'**

Many science teachers take great pride in their practical skills. Many eschew the chance of working at a senior management level because they really enjoy teaching and passing on their technical skill; some become advanced skills teachers and cover a number of schools. If this describes a teacher at your school, consult them regularly for useful advice. They will know what goes right and what goes wrong.

**After school science club for staff**

Science clubs are for pupils surely! No, by getting the teachers and technicians together, individuals can share their expertise. Many teachers are very wary of new equipment and ideas and it is those who are most unsure of themselves that find reasons not to attend. There is also pressure from senior management to attend other meetings as well.

**Specialist schools**

In your area there will be a science specialist school or college which should '*develop a rich repertoire of teaching and learning strategies, including through the imaginative use of ICT, and involvement in subject associations, industry, local and national developments and initiatives and competitions relevant to science and mathematics'*. Many of these schools and colleges organise meetings for teachers.

**Teacher training days**

This is another opportunity for teachers and technicians to find time together for some science skills revision.

**Association for Science Education**

It is of enormous concern that not all science teachers are members of this important professional body. There are many examples of practical work in its Journal, *School Science Review*. Even old editions, buried in schools or libraries, contain useful activities, but do check the safety aspects. The ASE offers professional development courses as well as regional meetings, and the Annual Meeting in January. At these events practical work is often carried out. See www.ase.org.uk. The book *Safeguards in the School Laboratory* (2006) is essential reading for all new science teachers.

**CLEAPSS and SSERC**

These organisations, www.cleapss.org.uk and www.sserc.org.uk (Scotland) supply written information on practicals and have a telephone help service to answer all your queries. They also provide a range of professional development courses for teachers and technicians.

**Science Learning Centres**

These centres have a full programme of professional development courses. See www.sciencelearningcentres.org.uk.

**The Scientific Societies: Institute of Biology, Institute of Physics Royal Society of Chemistry and the Royal Society**

These societies know that an investment on their part will supply the scientists we need for the future and they all have extensive education programmes. You can go to CERN to see the particle accelerator, visit the chemical industry sites. All these organisations offer local and national events of one sort or another. Further information can be found on the relevant web sites.

The Royal Society of Chemistry has published several important books of chemistry demonstrations and experiments which been risk assessed. *Classic Chemistry Demonstrations,* 1995, (ISBN 1870343387) is still available and contains 100 risk assessed activities. These types of books are not 'best sellers' and will ultimately, if not already, find their way onto the RSC web site (www.rsc.org).

**Practical science on the web**

www.practicalchemistry.org, www.practicalphysics.org and www.practicalbiology.org are available on-line with an extensive range of experiments that have been checked for safety.

**Universities**

If a local University has a thriving science department, you might find some interesting information there. University staff are often willing to talk or demonstrate to pupils but this is not the same as helping teachers understand and develop their teaching. However, planning local Science Olympiads can help develop links with Universities.

**Teachers TV**

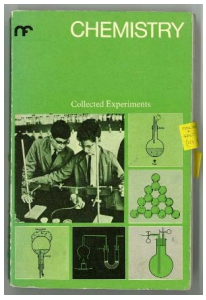
Science practical work is demonstrated on Teachers TV. The videos can be viewed or downloaded from the site www.teachers.tv/video/browser/1021.

**Science and Plants for Schools (SAPS)**

This site (www-saps.plantsci.cam.ac.uk) contains many useful experiments.

**Science text books**

A frequent criticism of some modern science textbooks is that they skimp on important detail. Vague terms such as 'dilute', 'spatula full' and 'heat' should warn you that the experimental details are not sufficiently precise. You need to try out the activities to establish concentration, the weighed amount and heating to a certain temperature or for how long.




Older science text books will go often into detail but may gloss over safety features. You will still find the book from *Nuffield Science 'Collected Experiments'*, published in 1967 on many shelves in schools and in second hand bookshops. It was an important book in its time and still contains many useful experiments. Many excellent practical activities and demonstrations, which first appeared in older Nuffield publications, have been updated and safety advice revised. They can be found on www.practicalchemistry.org, www.practicalphysics.org, and www.practicalbiology.org.

**Warning**

Downloading and trying experiments from the web can be very dangerous because there is no certainty that they have been rigorously checked for safety. If in doubt, members can always consult CLEAPSS on the ***Helpline***.

# Appendix 1: Some examples of practical activities where special care is needed (in alphabetical order)

Always check guidance in CLEAPSS publications.

| | |
|---|---|
| **Air rifle.** | Use it responsibly. Do not wave it about. Air rifles must be fixed to the bench in use. Eye protection is needed. |
| **Bangs and explosions.** | The hydrogen / oxygen explosion is a very loud bang and been known to cause deafness in the teacher and pupils. The teacher should wear ear defenders and get pupils far away with hands over the ears. |
| **Bromine liquid.** | Always have experienced help at hand when using this chemical for the first time. Gloves and a fume cupboard are essential. |
| **Chlorine.** | Always have experienced help at hand when using this chemical for the first time. A fume cupboard is essential. |
| **Electrical circuits and equipment.** | In demonstrations, always have complicated circuits or set-ups checked. |
| **Enzymes.** | Activities can be unpredictable. Always trial the experiment first. |
| **Gases and vapours.** | Do not deliberately inhale gases and vapours including helium and hydrogen. |
| **Liquid nitrogen and solid carbon dioxide.** | Always have experienced help at hand when using these for the first time. Gloves are essential. Storage is not straightforward and it can be very expensive. |
| **Mains electricity.** | Working directly with the mains is very hazardous. |
| **Microbiology.** | Aseptic technique needs rehearsal by the teacher. |
| **NEVER add water to concentrated acid – always work alphabetically: A to W.** | The addition of concentrated acids to water is exothermic. The sulfuric(VI) acid / water reaction particularly dangerous. |
| **NEVER approach or interfere with a reaction mixture that 'has not worked' until it has fully cooled.** | Follow the firework code. And have a large beaker of water on hand to plunge the chemicals and container into. |
| **NEVER do the iron / sulfur reaction on a tin lid in the open lab – sulfur catches fire, producing TOXIC sulfur dioxide.** | Sulfur dioxide in the room can cause asthmatic attacks. |
| **NEVER test for hydrogen with a lighted splint close to where the gas is being generated.** | Hydrogen / air mixtures are explosive. |
| **Outside the lab demonstrations, school field demonstrations, for…** | …Eg, water rockets and commercial fireworks. You may well be upsetting other classes overlooking the event and local neighbours who may well phone the police reporting an explosion at the school. Head Teacher's permission should be sought. You will also require extra teacher help in supervising the pupils. |
| **Plant work in the winter.** | Ordering daffodils flowers in autumn and photosynthesis in January is not going to be easy. |

| | |
|---|---|
| **Potometers and transpiration.** | Always tricky and need setting up really carefully to ensure they work. |
| **Radioactivity.** | Careful procedures are required but the rewards are great. (The sources used in schools are NOT going to damage your health.) |
| **Salt preparations.** | When making copper(II) sulfate(VI), do ensure that the copper(II) oxide has fully reacted with the acid. When making iron(II) sulfate(VI) and magnesium sulfate(VI) from the metal and sulfuric(VI) acid, ensure that the metal has fully reacted with the acid.<br>If pupils begin to concentrate the acid rather than the salt, the acid will decompose on heating producing white corrosive sulfur trioxide fumes. You will need to evacuate the laboratory. |
| **Scaling up reactions.** | You can always scale a chemical reaction down. Scaling up can cause particular problems. Seek advice first. |
| **Students as the subject of an activity.** | Eg, using the Van de Graaf generator, running up and down stairs to find pulse rates, discussing family tree. No children should be persuaded to take part unless they genuinely wish to do so. |
| **Suckback.** | This frequently occurs when cracking hydrocarbons or heating carbonates, testing for carbon dioxide with limewater. The as the apparatus cools, water sucks back into the hot tube and cracks it. Just lift the apparatus away from the cold water. |
| **Tasting experiments and making food.** | Eg, ice cream or bread. These should not be carried out in a laboratory. Use a more appropriate room, such as that for food or the dining room. |
| **Theft of equipment and materials.** | Be vigilant in counting equipment back. And keep a careful eye on ‘exciting’ chemicals such as magnesium. If you discover anything missing, make a big fuss to get it back, otherwise you may be seen as an easy touch. |
| **Van de Graaff Generator.** | Great fun but only one child at a time should be insulated from the ground and charged. When two children are insulated and charged together, the shock experienced on discharge may be sufficient to frighten the child receiving it. |

# Appendix 2: References

### CLEAPSS publications

All CLEAPSS publications are available free to teachers and technicians in member schools. They are available electronically in a searchable format in the *Secondary Resources* section of the members' part of the CLEAPSS web site. You will need a user name and password to gain access and this is distributed annually to all members on the *Bulletin*. The *Science Publications CD-ROM*, sent in January to every secondary member school, has the same structure as the web resources and also contains the user name and password for the web site.

Some of the CLEAPSS documents referred to in this guide include…

Guide L248a, *Running a Prep Room*, which contains a range of technician requisition sheets. A customisable version, DL248, *Running a Prep rooms: Documents*, is available in the section: customisable documents.

Guide L196*, Managing Risk Assessment in Science* offers information on making and recording risk assessments.

Guide L234, *Induction and Training of Science teachers.*

### Association for Science Education

The ASE published a short book, which is essential reading for new (and experienced) science teachers:

*Safeguards in the School Laboratory* 11th Edition ASE 2006.

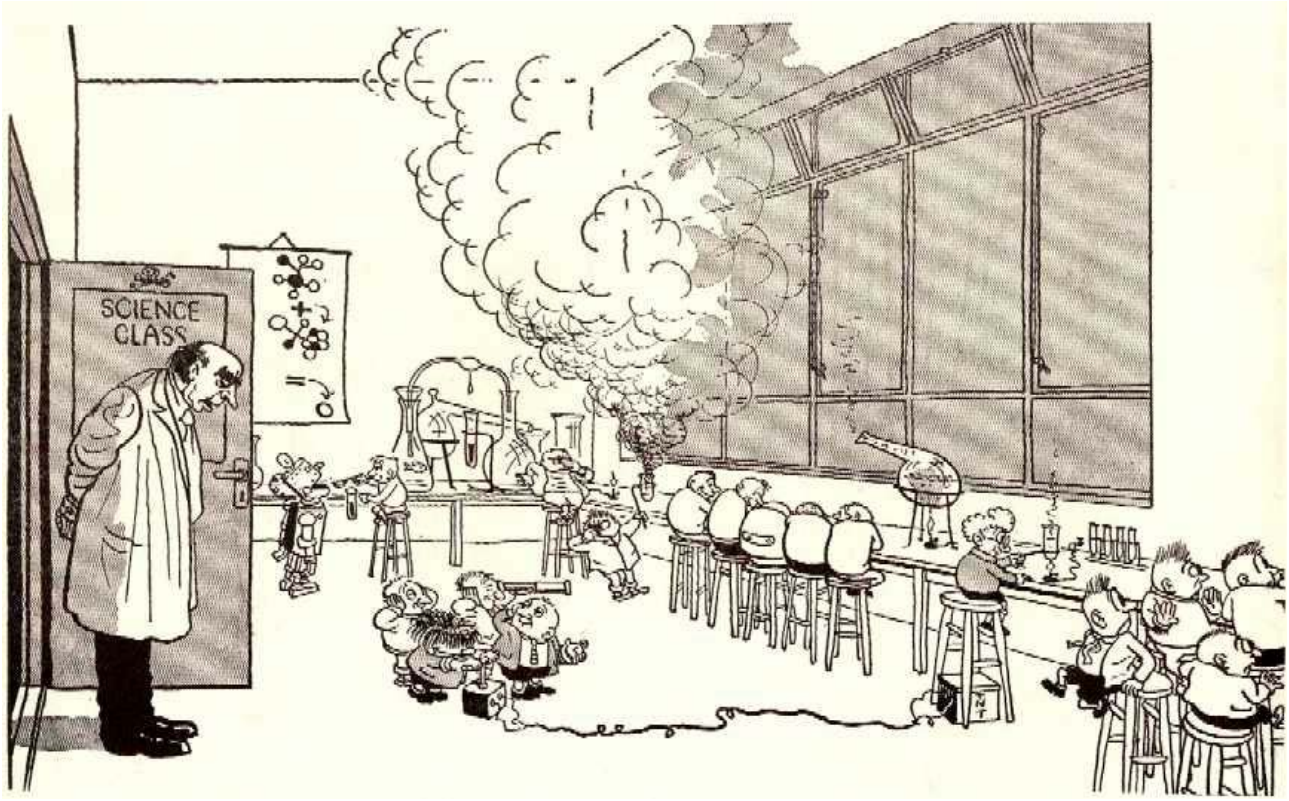
### National Strategy Publications

The following two publications were released in 2008 on a compilation set of DVDs entitled *Developing our future scientists in your school*. Copies of the DVD set were available from DCSF Publications 0845 60 222 60 under the reference number 00097-2008PCK-EN.

*Interactive Practicals – a science study guide.* REF: 00094-2008 DVD_EN. A copy can be downloaded from
www.nationalstrategiescpd.org.uk/file.php/163/interactive_teaching_science_v2/assets/study_guides/interactive_practicals.pdf.

*Effective Demonstrations – a science study guide.* Ref 00094-2008 DVD-EN. A copy can be downloaded from
www.nationalstrategiescpd.org.uk/file.php/163/interactive_teaching_science_v2/assets/study_guides/effective_demonstrations.pdf.

The Secondary national Strategy has produced an extensive range of resources to support science teaching. These are all available from http://nationalstrategies.standards.dcsf.gov.uk/secondary/science/.




“Blowing Bertie to smithereens isn’t going to help the Socialists Party’s call for more scientists, is it?”

Acknowledgements:
Carl Giles, the Daily Express, 3rd October 1963, the British Cartoon Archive,
University of Kent, www.cartoons.ac.uk